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ABSTRACT

This guide gives descriptions of common vertebrate pests and guidelines for using some common pesticides. The pests discussed are rats, mice, bats, moles, muskrats, ground squirrels, and gophers. Information is given for each pest on the type of damage the pest can do, the habitat and biology of the pest, and the most effective control methods. The pesticides mentioned are: (1) strychnine; (2) carbon bisulfide; (3) gas cartridge; (4) methyl bromide; (5) anticoagulants; (6) sodium nonfluoroacetate; and (7) zinc phosphide. Use, characteristics, pharmacology, and first aid information are given for each pesticide. (EE)

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VERTEBRATE PEST CONTROL

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VERTEBRATE PEST CONTROL

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INTRODUCTION

Vertebrate Pest Control has been prepared as part of a series of guides for pesticide applicator certification training in California. Unlike the other guides in this series, this one is not intended to be used in preparing for certification in any single specific category: there is no specific applicator category for vertebrate pest control in California. It has been made available for those who seek certification in any category, and whose pest problems may involve vertebrate pest control.

This guide does not provide all the knowledge needed for effective vertebrate pest control: additional information can be obtained from Cooperative Extension, University of California, and from your county agricultural commissioner.

This guide was edited by M. W. Stimmann and is a condensation of the *Vertebrate Pest Control Handbook*, compiled by Dell O. Clark, Division of Plant Industry, State of California, Department of Food and Agriculture. Additional assistance was provided by M. W. Cummings and D. A. Wade, University of California, Davis.

LEGAL STATUS

MAMMALS

Meadow mice, rats, bats, moles, house mice, ground squirrels, and pocket gophers are classified as nongame mammals by the California Fish and Game Code. Nongame mammals which are found to be injuring crops or other property may be taken at any time or in any manner by the owner or tenant of the premises, except that not have saw-toothed or spiked jaws or a spread of 5½ inches or larger without offset jaws. Nongame mammals may also be taken by officers or employees of the Department of Food and Agriculture, or by federal or county officers or employees when acting in their official capacities pursuant to the provisions of the Food and Agriculture Code pertaining to pests.

DEPREDATING BIRDS

The county agricultural commissioners in California may (without a permit) kill or cause to be killed under their general supervision certain depredating migratory birds including meadowlarks; horned larks; golden-crowned, white-crowned, and other crowned sparrows; goldfinches; house finches; acorn woodpeckers; Lewis woodpeckers; and flickers if they are seriously injuring agricultural or horticultural crops. This may also be done with a federal permit.

For details concerning this highly regulated area of pest control, contact your county agricultural commissioner, or the California Department of Food and Agriculture, or the U.S. Fish and Wildlife Service.

PEST MAMMALS

Rats (Norway rat, roof or black rat)

Damage. Rice, corn, melons, squash, asparagus, citrus, avocados, olives, and nuts are damaged by both species. Stored commodities may be eaten, or contaminated by urine, hairs, and feces. Rats may eat eggs and kill young birds. They may host trichina worms, and carry Salmonella, bubonic plague, and murine typhus. They may

gnaw woodwork, wiring, and clothing.

Range. Throughout lowland California, in urban and agricultural areas.

Habitat. *Norway rat:* warehouses, farm buildings, houses, irrigation dikes, sewers, rubbish dumps, wood piles, ships. Usually found within 1 story of ground level. *Roof rat:* buildings, especially around upper stories and attics, ships, warehouses, fields, stream banks, dense vines, palms, and other trees.

Biology. *Norway rat:* may dig or burrow along foundations of buildings, beneath rubbish piles, and in fields. Prolific breeders, their average length of life is about 1 year and litters are numerous and large. Norway rats are mainly nocturnal; but they may go about in undisturbed places during the day. They feed on virtually anything edible, but are unable to vomit. In general, they seem unable to establish themselves in the absence of food provided by human activity. *Roof rat:* an agile climber better adapted than the Norway rat to establishing populations in rural habitats. These rats are likely to nest in enclosed spaces in attics, walls, and cabinets. They are omnivorous, but show more preference for fruits and vegetables than do Norway rats.

These two species of rats may be distinguished by noticing that:

1. The tail of a Norway rat is shorter than its head and body combined.
2. Roof rats are smaller than Norway rats; the tail is usually longer than the head and body combined.

Control

Control measures for alien rats include sanitation, exclusion, trapping, and the use of toxic baits. No one technique is totally effective and a combination of all techniques is usually required for satisfactory control.

The removal of rat harborage and blocking all entrances into buildings can greatly reduce rat problems.

For limited infestations of rats inside buildings, the use of several wooden base rat traps is usually efficient to obtain control.

To control larger infestations, toxic bait may be necessary. Cereal baits, both loose or embedded in paraffin, are widely used. Baits are available in many garden or farm supply stores or from many county agricultural commissioners.

Cereal baits treated with a chronic toxicant and embedded in paraffin are used in sewers, outdoor placement, or other excessively damp locations where unprotected bait would spoil rapidly. The bait blocks are reasonably weatherproof, eliminating the need for bait stations. As old blocks are eaten away, replace with new one. Bait should be picked up and disposed of upon completion of rodent control program.

Note: Paraffin bait blocks are not as readily accepted as comparable bait in the loose form; paraffin bait blocks should only be used where environmental conditions demand a moisture resistant type bait or use of loose bait is impractical.

Meadow Mice (field mice, voles)

Damage. Alfalfa tops and roots, native meadows, permanent pasture, and hay; cole crops, carrots, sugar beets, potatoes, grains; bark of citrus, cherry, olive, and other trees and shrubs.

Range. Throughout California.

Habitat. Meadow mice are likely to be found where there is good grass cover. They generally do not invade cultivated crops until the crop is tall enough to provide food and shelter.

Biology. Meadow mice are active all year round irrespective of weather. They forage at any time during the day or night, but are chiefly diurnal. They are usually found in colonies marked by numerous 1- to 2-inch wide surface runways

through matted grass leading to shallow underground burrows. Small piles of brownish feces and short pieces of grass along the runways are evidence of activity.

Meadow mice populations build up to a peak every 3 or 4 years, followed by a rapid decline during the next breeding season. In cultivated areas meadow mice populations probably are permanently based in favorable habitat such as roadsides, canal banks, or adjacent noncultivated land. Invasion of cultivated cropland occurs when the population builds up or when the wild habitat becomes unfavorable, as when range grasses dry up in summer.

Control

Proper vegetation management will go far in preventing populations of meadow mice from building up. Once populations have built up, the use of treated grain baits may be necessary. These baits are available from most county agricultural commissioners.

Bats

Damage. Bats inhabiting buildings produce offensive odors and distracting noise. Bats can carry rabies, but transmission of rabies need not be from a bite from an infected bat: there is evidence that exposure of abraded skin to bat urine or even inhalation of cave air may be infective. Eight species of bats in California have been found to be sometimes infected. There are no true bloodsucking bats in the United States; a bite is unlikely unless one is handling bats.

Range. Throughout California.

Habitat. Bats are nocturnal, roosting in crevices, caves, tunnels, tree foliage, or buildings during the day. Many species inhabit the same roost throughout the year.

Biology. Bats are the only mammals which are true flyers, as opposed to gliders such as flying squirrels. Most species of bats are colonial, but some are solitary; both conditions occur in some species. Bats have few enemies (owls, snakes) and some may live 20 years or more.

Control

Repellents–

Bats may be driven out of attics or other enclosed spaces by spreading repellents in the area. If the area does not lend itself to spreading the material, it may be suspended from rafter(s) in cheesecloth bags. The material dissipates upon exposure to air and repeated applications may be necessary if entrance holes are not plugged after the bats have left. After the bats have left the treated area, seal off openings by which they are gaining entrance to the building with strips of wood, metal, or creosoted caulking compound.

New individuals may be attracted by the odors left by departed bats. Therefore, a thorough clean up and bat-proofing should be considered necessary adjuncts to the use of repellents.

Moles

Damage. Molehills and tunnels disfigure lawns and gardens and interfere with hay harvesting and machinery. Some moles may eat tubers and roots of garden plants.

Habitat. Moles are found in soft soils, such as those of gardens and lawns.

Biology. Moles are active the year round, and most moles are equally active by day and night. The shrew mole spends considerable time on the surface of the ground, but other mole species rarely venture out of their tunnels. Mole tunnels are of two types: temporary surface tunnels where the sod is raised; and deeper tunnels from which the mole must excavate dirt, forming molehills. Moles are generally solitary.

All moles eat worms and insect larvae chiefly, and many eat some vegetable matter as well. Their sight is very poor; they are sensitive to odors and ground vibrations.

Control

Toxicants–

Indirect control with toxicants: if moles are deprived of their food supply, they will be forced to seek another area. Several insecticides are capable of reducing the population of earthworms and soil insects to a point where the soil no longer provides sufficient food to fulfill the mole's daily requirements. The effect on the mole population cannot be expected for several weeks following treatment. This method of control is most suitable for turf areas. Indirect mole control through the reduction of food supply is a comparatively expensive measure, but it is useful on turfs where moles are a constant threat.

Trapping–

Trapping is the most universally applicable and dependable method of mole control. A number of different mole traps are available. Most mole traps utilize the theory that a mole will push its way into a soil block in its tunnel. For this reason, traps are generally set so that they straddle the runway, encircle it, or are suspended above the runway. They are usually sprung by the pressure of the mole's body or the movement of soil against a triggering plate.

Before setting traps, determine which runways are in current use. To determine activity, stamp down short sections of runways and molehills and observe daily; restamp any raised sections or mounds. Deeper runways may be located by probing downward with a pointed rod or a standard gopher probe between (or next to) fresh molehills. The selection of a main or frequently used runway in which to set a trap is of prime importance for successful control.

Muskrats

Damage. Muskrats damage rice, milo, sugar beets, and tomatoes. Much crop damage attributed to muskrats in the Delta area is actually caused by resident Norway rat populations. The major damage done by muskrats is caused by their burrowing in earthen banks. This weakens levees, culverts, and head gates, which eventually wash out; the problem is more serious where levee soils are peaty or sandy, and where ditchbank walls are thin.

Habitat. Marshes, edges of ponds, lakes, and streams; cattails, tules, water lilies, and open water are preferred by muskrats.

Biology. Muskrats are almost always found near water. They may wander overland in search of new feeding grounds, or to escape floods.

Muskrats may live in burrows in banks, or they may build conical houses 3 or 4 feet in height out of reeds in ponds or marshes. There may be one or more entrances, which are generally underwater.

Muskrats are primarily vegetarians, eating cattails, tules, and other aquatic plants, bulbs, grasses and some animal food such as snails.

Muskrats are more active by night than by day and do not hibernate.

Control

Treated baits and the use of fumigants are effective in controlling muskrats. These materials are available from most county agricultural commissioners.

Trapping–

Muskrats are not difficult to trap. Traps should be chained to a stake in the water so that the muskrat can swim away from the bank and drown.

Muskrats frequently make burrows about junctions of irrigation canals. Such burrows may lead

from one canal to another, often beneath the protection of the structure. Differences in water level cause burrows to erode rapidly. To help prevent burrowing, impregnate soil with a repellent material, such as crankcase drippings. The head gate should have a concrete apron extending 15 feet in both directions from the head gate along the sides and bottom of the canal. Wire netting may be used on canal banks to prevent burrowing.

Legal status. Muskrats are classified as furbearing mammals by the California Fish and Game Code; however, muskrats that are injuring growing crops or other property may be taken at any time and in any manner, except that if leg-hold steel-jawed traps are used they shall not have saw-toothed or spiked jaws or have a spread of over 4¾ inches.

House Mice

Damage. House mice consume and contaminate stored grain and cereal products as well as fruit, vegetables, cheese, meat, and hay. They often consume the feed in chicken houses. Other property damage, including gnawing electrical wiring, may occur. Mice and their fleas and lice may transmit diseases.

Range. Throughout California where there are concentrations of people.

Habitat. Occasionally found in fields, but usually in buildings. House mice build nests in boxes and crates as well as in stationary objects. Nests in crates are often moved along transportation routes.

Biology. Mice living in the open may move into buildings when weather becomes severe. House mice soon become accustomed to ordinary noises and as a result may be active in areas near people, animals, or machines.

House mice eat the same foods as do humans. Different environments offer varied diets and sometimes mice will feed upon live insects, starch in clothing, and glue in bookbindings. Mice require very little water and can live on a diet of dry grain. They are active day and night. They range less than 30 feet from their nest, which may be constructed of soft material such as cotton or paper, and may be built in walls, cabinets, or other convenient space.

Control

Toxic grain baits available from many county agricultural commissioners may be used to control house mice where trapping is not feasible. Because house mice have a small home range, treated bait must be exposed every 8 to 12 feet in the infested area.

Trapping—

When one or a few mice are present, ordinary mouse traps baited with peanut butter or bacon will often solve the problem. Place the trap in a covered area near the base of a wall or other structure with the trigger end of the trap facing the wall.

Ground Squirrels

Damage. Grain (all types), fruits and nuts including almonds, apples, apricots, peaches, pistachios, prunes, oranges, tomatoes, and walnuts. Certain vegetables and field crops such as sugar beets and cotton are damaged during the seedling stage. Young orchard trees are sometimes damaged by gnawing of the bark.

Ground squirrels can significantly reduce the amount of green foliage available to grazing cattle during winter when plant growth is slow.

Ground squirrels may damage levees and ditchbanks by burrowing. They may also cause unacceptable damage to golf courses, railroad rights-of-way, pastures, and cemeteries.

Ground squirrels are frequently associated with the transmission of plague, Rocky Mountain spotted fever, tularemia, and other diseases.

Habitat. Some ground squirrels inhabit meadows, green fields, or their edges. Other species live on natural rangeland, pastures, grain fields, slopes with scattered trees, and rocky ridges.

Biology. Ground squirrels are active during the day and are often seen out of their burrows during warm sunny weather. They are basically ground-living foragers although some may climb trees for nuts and fruits. All species of ground squirrels dig burrows for shelter, safety, food storage, and nesting. They do not plug the entrances of their burrows.

Ground squirrels emerge from hibernation in late winter or early spring. They are active for a while and then may enter into a "summer sleep" (estivation); this is usually followed by a period of activity before hibernation.

Ground squirrels breed during the first half of the year, and produce a single litter each year.

Control

Limited infestations, such as in gardens or "backyard situations", may be controlled by trapping.

Infestations in agricultural situations may require the use of fumigants or toxic grain baits which are available from many county agricultural commissioners. Some treated bait is available from garden or farm supply stores.

Gophers (pocket gophers)

Damage. Alfalfa, lawns, root and bulb crops, trees, shrubs, vines, herbaceous plants, and range meadows. Mounds interfere with harvesting hay and grain crops; they may also cover up plants. Gopher burrows may weaken banks of ditches and canals. Gophers may sometimes gnaw underground cables.

Habitat. Valleys and mountain meadows are the most typical habitat. Lawns and gardens are frequently inhabited by gophers. Gophers are most abundant in better soils and where ample moisture and plant growth prevail.

Biology. Food consists mainly of the underground parts of plants, especially the succulent portions. Pocket gophers lead an almost completely subterranean existence, venturing above ground only to push dirt out of the burrow, seek new territory, or to graze on succulent plants.

Gopher burrows consist of main tunnels running more or less parallel to the soil surface. Accumulated dirt is pushed from the excavations to form characteristic crescent-shaped mounds of soil.

Gophers do not hibernate or become completely inactive at any time of year.

Control

In agricultural situations or infestations in large areas the use of toxic baits may be necessary. A few commercial bait preparations are available in garden or farm supply stores. Bait is also available from many county agricultural commissioners.

Fumigation—

The extent of the burrow system, the chance for leakage of the gas throughout the soil, and the fact that gophers may plug off their burrows when a poisonous gas is detected all make the use of gas unsatisfactory. Gopher "bombs" are usually unsatisfactory and relatively expensive.

Trapping—

For cleanup work or for small areas such as lawns or gardens where only a few animals are involved, trapping is an effective means of control. Runways are located with a probe, then dug open, and the traps are inserted. Traps should be secured with wires attached to a stake. Two traps

should be inserted in the main runway facing opposite directions.

Flooding–

Irrigated croplands and orchards are periodically flooded and gophers either drowned or forced out by the incoming water. Those driven to higher ground are easily killed by a good dog or a stroke of the irrigator's shovel.

Mechanical burrow builder baiting–

On extensive areas use a "burrow builder" machine to make artificial burrows 20 feet apart across the field at the same depth as natural burrows. The machine drops bait automatically at intervals in these tunnels.

Consult the machine operating manual for specific instructions.

PESTICIDES

Safety Precautions

All bags, sacks, or other containers should have the word "POISON" stenciled or printed directly on them. This is in addition to the normal labeling requirements.

Toxic baits and concentrates shall be stored in an adequately locked space at all times when not in use. Such space shall be entirely separate from where food or drink for humans or domestic animals is kept or stored.

All persons handling toxic baits or concentrates should be advised as to:

a) The characteristics of these materials.
b) The necessity of using adequate protective clothing and devices such as gloves and/or bait spoons for dispensing baits.
c) The necessity for keeping all skin abrasions and cuts adequately protected.
d) The possibility of inadvertent poisoning of wildlife and domestic animals by improper bait exposure.
e) The symptoms of poisoning in people, and the recommended first aid if such symptoms occur.

To prevent the accidental spillage of toxic grain, containers (including sacks, shoulder bags, and saddle bags) should be so designed and in such repair that leakage or spillage does not occur. Shoulder bags should be equipped with a closing device. Equip saddle bags with a zipper or drawstring for quick closing.

Toxic bait accidentally spilled should be immediately and thoroughly cleaned up.

Do not leave containers or prepared bait unattended, or where they can be obtained by children, irresponsible persons, or animals.

Unused baits should be returned to the local agricultural commissioner or disposed of in a Class I dump.

Burn empty bait containers (check local regulations).

Wash hands with soap and water after handling poison baits and before eating or smoking.

Guidelines For Baiting Field Rodents

Pre-treatment

Actual damage or threat of damage must be sufficient to warrant application of rodent baits. As a safeguard to humans and domestic animals, alternative methods such as fumigants or anticoagulant baits in bait boxes should be considered in preference to broadcasting acute toxic baits around inhabited buildings or suburban areas and domestic animals.

Baiting shall not be done unless tests indicate satisfactory bait acceptance occurs in areas to be treated.

Bait should be chosen on the basis of selectivity as well as acceptance value.

Treatment

Toxic baits used in control operations shall be artificially colored or dyed in accordance with suggestions contained in the *Vertebrate Pest Handbook*.

Quantities of toxic bait exposed shall be regulated so that residual bait will not present a hazard to non-target species.

Property owners or tenants shall be advised to dispose of rodent carcasses on the ground surface immediately adjacent to inhabited areas. A shovel or pitch fork should be used to minimize possible contact with ectoparasites.

There are no specific statutory provisions requiring the posting of warning signs for rodent control. However, when premises are posted in accordance with county policy, they are to be posted as prescribed by the Penal Code, Section 596 – "...signs located at intervals of distance not greater than one-third of a mile apart and in any case not less than three such signs having words with letters at least one inch high reading 'WARNING – POISON BAIT PLACED OUT ON THESE PREMISES'..."

USE OF PESTICIDES

To be most effective each pesticide must be used according to specific instructions. These instructions can be found on the label accompanying the pesticide. REMEMBER: It is a violation of state and federal laws and regulations to use any pesticide in a manner inconsistent with its labeling.

> As of January 1977 each of these pesticides was registered for use against one or more vertebrate pests. However, continued use of several of these compounds is being questioned by the U.S. Environmental Protection Agency. Before using any of these pesticides you should contact your local county agricultural commissioner for up-to-date information.

Strychnine

Use. Strychnine is a widely used toxicant registered for use in controlling certain rodents and depredating bird species.

Characteristics. Strychnine, a white crystalline powder, is available in an alkaloid and a sulfate form. It has a characteristic bitter taste. Strychnine alkaloid is almost entirely insoluble in water and very stable.

Pharmacology. Strychnine acts the quickest of the commonly used rodenticides excluding fumigants. It is not cumulative, not absorbed through normal intact skin, has a very slight odor, has very high toxicity, and is somewhat variable in action against target animals. Strychnine enters the blood very rapidly and acts on the central nervous system. Animals with little in their stomach react more quickly to strychnine than those that have fed recently. Symptoms may appear in from five to thirty minutes after ingestion.

Toxicity. *Primary:* the LD_{50} to dogs is about 0.70 mg/kg; a lethal dose for pigs is about 10.0 mg/kg. Livestock are about as sensitive to

strychnine as rats. *Secondary*: strychnine is not assimilated into tissues or bone as is the case with Compound 1080 (see below); however, residues in the intestinal tract of animals poisoned with lethal doses are known to be potentially hazardous if consumed.

First aid. If less than 10 minutes has passed since the poison was taken, induce vomiting by giving a tablespoon of salt in a glass of water. However, if symptoms have begun, avoid vomiting because this may initiate a convulsion which might lead to the inhalation of vomitus. Have the victim lie down in a darkened and quiet room if possible and remain quiet and warm. Enforce absolute quiet and absence of stimuli. Call a doctor immediately.

Carbon Bisulfide

Use. Carbon bisulfide is a liquid which quickly volatilizes and is used as a rodent and insect fumigant.

Characteristics. The name carbon bisulfide is used interchangeably with carbon disulfide. This material is a clear, colorless (turns yellow when exposed to sunlight), volatile liquid. Its vapors are 2.5 times heavier than air and will flow to the lowest parts of a rodent burrow.

Pharmacology. Carbon bisulfide is harmful by inhalation of the vapor, prolonged or repeated contact of the liquid with the skin or by oral intake.

Toxicity. Acute poisoning is rare. Sudden exposure may produce headache, nausea, dizziness, and, if prolonged, lead to circulatory collapse and unconsciousness. A concentration of about 4,000 ppm may be fatal after an exposure period of ½ to 1 hour.

Chronic poisoning results from continued or frequently repeated exposure to relatively low concentrations of carbon bisulfide. It probably occurs only from inhalation of vapor and is insidious in development. The most serious forms result in acute mental disturbance or in severe injury to the nervous system.

Contact with the skin may cause only a temporary reddening and a burning sensation; however, if the liquid is not allowed to escape by evaporation there may be extreme pain almost immediately, and later a more or less severe chemical burn.

First aid. Call a doctor. If atmosphere is contaminated, move the victim to fresh air. Apply artificial respiration if breathing has stopped. If oxygen is available and you are trained in its use, give oxygen. Keep victim warm.

Remove contaminated clothing and wash skin thoroughly with water.

If liquid carbon bisulfide has been splashed into the eyes, wash them promptly with a clean, gentle stream of water for at least 15 minutes. Get the victim to a doctor.

If swallowed and victim is conscious, induce vomiting with salty or soapy water. Repeat this procedure at least three times.

Chronic poisoning may produce sudden hysteria or violent behavior. If necessary, tie the victim's arms and legs to prevent injury. A patient suffering from psychic disturbance due to carbon bisulfide should always be hospitalized.

Gas Cartridge

Use. Gas cartridges are devices designed to give off gases and smoke when ignited. They are used as a rodent fumigant.

Pharmacology. When ignited, the cartridges emit smoke and toxic gases. Carbon monoxide gas, similar to that from an automobile exhaust, is a major product. Carbon monoxide poisoning produces a feeling of tightness across the forehead, headache, throbbing at the temples, dizziness, weariness, nausea, vomiting, collapse, and unconsciousness.

First aid. Remove the victim to fresh air and have victim lie down. If breathing has stopped, apply artificial respiration. Use oxygen inhalator only at the direction of a physician. Call a doctor immediately.

Methyl Bromide

Use. Methyl bromide, a liquid when under moderate pressure, is usually packaged in 1-pound cans or larger metal cylinders. It is used as a fumigant for rodents, insects, soil pests, and agricultural commodities.

Characteristics. Methyl bromide is a colorless liquid which boils at 4.5° C (40° F). At ordinary temperatures it is a nonflammable gas. Methyl bromide is 3.5 times heavier than air. It has a burning taste and slightely chloroform-like smell.

Pharmacology. Methyl bromide is harmful by inhalation of the vapors; injury may also occur by eye or skin contact with the liquid. In acute exposures by inhalation the effects are on both respiratory and central nervous systems; these effects may be delayed.

Methyl bromide will act as a lung irritant in the respiratory system. Effects may vary from mild bronchitis all the way to pulmonary edema and respiratory failure. Signs and symptoms may include cough, chest pain, difficult or painful breathing, and eventually "wet" breathing often complicated by broncho-pneumonia.

Central nervous systems usually accompany or follow the respiratory effects by several hours. Signs and symptoms include intense nausea and vomiting, dizziness, blurred vision, staggering gait, and blurred speech. Convulsions are an ominous sign.

Because methyl bromide has a very low boiling point, evaporation takes place rapidly and within seconds it has disappeared from the surface of the skin. However, if methyl bromide is spilled on clothing, gloves, or shoes, such coverings may become saturated and the material may remain in close and continuous contact with the skin. There is no particular sensation produced by such contact, and the individual may be unaware that exposure has occurred. As a result, burns similar to thermal burns may occur.

No person should be permitted to handle methyl bromide while wearing gloves or close-fitting dressings. Methyl bromide will penetrate ordinary rubber gloves, so these should not be worn. If methyl bromide has been spilled on the clothing, such clothing should be carefully aerated before being reworn.

Severe corneal burns may result from splashes of the liquid material in the eye. Vapor exposures to the eye will cause irritations but burns are unlikely.

First aid. The patient should be removed from further exposure to the poison. If there has been a liquid contact, all contaminated clothing should be removed and the skin washed with running water for at least 15 minutes. If breathing has stopped, apply artificial respiration. Take the victim to a doctor at once.

Anticoagulants

Use. Anticoagulants are multiple-dose rodenticides used widely for control of rodents in or near human habitations. Anticoagulants are also used for deer mouse control in reforestation projects, and are becoming widely used in field rodent control.

Characteristics. Anticoagulant compounds used as rodenticides are composed of two groups based on their chemical structure: the hydroxycoumarins (e.g., warfarin and fumarin) and the indandiones such as Pival, diphacinone, PMP, and chlorophacinone.

Most anticoagulants are quite stable compounds and their sodium salts are soluble enough in water to allow their use as lethal water baits.

Pharmacology. Anticoagulants have two actions: they reduce the clotting ability of the

blood and cause damage to the capillaries (tiny blood vessels). They may cause death if consumed in sufficient quantity over a period of days.

Anticoagulants must be fed upon several times over a period of days. With repeated daily doses the effective toxicity of the compound is greatly increased. Feeding does not have to be on consecutive days, but several feedings should occur within a 10 day interval with no longer than 48 hours between feedings. It is important that plenty of bait be available at all times to achieve adequate control, since anticoagulants seldom kill by a single dose.

Toxicity. Anticoagulants have the same effect on nearly all warm-blooded animals and many birds, although poultry are quite resistant.

Relatively low dosages of anticoagulants are fatal to rodents when ingested by multiple feedings over a period of several days. The same amount ingested at a single feeding may produce no significant effects to the rodent. While anticoagulants can be lethal to mammals and birds, household pets would have to consume large quantities of rodent bait by multiple feedings over a period of several days to induce fatal results.

There is little danger to livestock unless animals are in barns or sheds where uncovered bait has been placed. Cereal baits are attractive to dogs that have been fed regularly on dog biscuits or meal. There are recorded cases of dogs, cats, and pet birds affected by anticoagulants.

Danger to children can be eliminated if bait is placed out of reach.

Bait boxes with small entrance holes should be used. Other safe places to place bait are behind cupboards or in similar areas difficult to reach. Temporary shields may be nailed to walls or to skirting boards in sheds or storage areas. Humans, like animals, must eat the bait daily for an extended period to produce serious effects. A large single dose eaten at one time would have little effect.

Some important factors to remember about the toxicity and use of anticoagulants are:

Increased dosage levels of anticoagulants may not always bring about increased toxicity, especially if bait ingestion occurs daily.

Excessively large doses have little influence on shortening the time till death if the bait is constantly available to the rodents.

If the concentration of some anticoagulants is increased in the bait, above that recommended, bait acceptance may diminish significantly with some species.

Rats appear to detect and discriminate against certain anticoagulants and their sodium salts in water solutions at a much lower level than if the same material was prepared in a solid bait.

First aid. In the case of accidental ingestion by a person, induce vomiting at once. Contact a doctor for additional treatment.

Sodium Monofluoroacetate (Compound 1080)

Use. Compound 1080 is applied to grain baits with a lecithin-mineral oil emulsion. Treated baits are usually used for the control of ground squirrels, but may also be used to control various other species of rodents.

Possession. The possession and use of sodium monofluoroacetate is restricted in California by provisions of the Food and Agricultural Code and by Regulations of the Director Concerning Sale, Use and Possession of Sodium Fluoroacetate.

Characteristics. Sodium monofluoroacetate is a white, stable, water-soluble, practically tasteless, crystalline compound. It has a faint acetate odor and a mild acid-salty taste. When the powdered material is exposed to air, it takes up water and becomes gummy.

The material is extremely soluble in water and relatively insoluble in many organic solvents and in vegetable fats and oils. A black dye has been added to the compound so it may be distinguished from sugar, flour, etc.

Pharmacology. The primary pharmacological action of "1080" may be either in the central nervous system or on the heart or a combination of the two symptoms depending upon the subject involved. There is no practical antidote for "1080" poisoning; treatment is symptomatic.

Toxicity. An outstanding characteristic of the toxicity of "1080" is the extremely wide variation on susceptibility between different species of animals. Dogs have been killed with a dosage of "1080" as small as 0.06 mg/kg but a Norway rat may require 8.0 mg/kg. The amount necessary to produce lethal effects often varies in different strains of the same species.

Judging from fatal and near fatal cases, the dangerous dose to man is 0.7 to 2.1 mg/kg. Other species vary considerably in their response, with primates and birds the most resistant, and carnivores and rodents generally the most susceptible.

It is generally agreed that secondary poisoning can be demonstrated with sodium monofluoroacetate. However, simple dilution and the fact that animals can metabolize "1080" to nontoxic metabolites or excrete a large quantity of a dose prior to death if the dose is approximately an LD_{50} considerably reduces the hazard of acute poisoning via secondary sources.

First aid. If swallowed, speed in treatment is essential. Immediately give a tablespoonful of salt in a glass of warm water and repeat until vomitus is clear. Then, give two tablespoonsful of Epsom salt in water. Have victim lie down and keep warm and quiet. Call a doctor immediately.

Zinc Phosphide

Use. Zinc phosphide, at concentrations of 0.75 percent to 2.0 percent on grain, fruit, or vegetable baits, has been used successfully against such species as meadow mice, ground squirrels, Norway rats, cotton rats, and nutria. In some areas of California zinc phosphide baits have been partially or completely rejected by ground squirrels and meadow mice, and at times control has been erratic.

Characteristics. Zinc phosphide is a heavy, finely ground gray-black powder that is practically insoluble in water and alcohol. When exposed to moisture, it decomposes slowly and releases phosphine gas. Phosphine, which is highly flammable, may be generated rapidly if the material comes in contact with dilute acids. Zinc phosphide concentrate is a stable material when kept dry and hermetically sealed.

Although zinc phosphide baits have a strong, pungent, garlic-like odor, this characteristic seems to attract rodents, particularly rats, but apparently makes the bait unattractive to some other animals.

There is only a small amount of deterioration of zinc phosphide on baits due to the evolution of phosphine gas; therefore, dry baits must be considered toxic.

Under field conditions, zinc phosphide baits may remain toxic for several months until eroded by weathering or decomposition of the carrier, or until the grain is removed by insects. Physical erosion does not seem to occur rapidly.

Pharmacology. When zinc phosphide comes into contact with dilute acids in the stomach, phosphine (PH_3) is released and this substance probably causes death. Animals that ingest lethal amounts of bait usually succumb overnight with terminal symptoms of convulsions, paralysis, coma, and death from asphyxiation.

Early symptoms of zinc phosphide poisoning are: nausea, vomiting (yielding black stomach contents and smell of phosphine), abdominal pain, chest tightness, excitement, and a feeling of coldness.

Toxicity. Zinc phosphide is poisonous to some degree to all animals. The odor and dark color of zinc phosphide (supposedly safety factors) may be of little importance in some situations. As little as a teaspoonful of bait containing zinc

phosphide could cause toxic symptoms in a child to whom the color and odor may not be disagreeable. Therefore, around dwellings, bait should be exposed only in situations that will prevent pets and children from contacting it.

Use extreme care in handling zinc phosphide concentrate and treated bait. If zinc phosphide baits are prepared in the open air, phosphide generated from the moist bait offers little hazard. Zinc phosphide dust created by the preparation or handling of baits is hazardous. Personnel working indoors should wear appropriate respirators and work under exhaust fans. **Zinc phosphide baits should not be mixed or distributed with the bare hands.** Oils, liquid or semi-solid, are used in some preparations and, since phosphorous is soluble in certain fatty oils, the poison may be absorbed in small amounts through the skin.

There are no specific antidotes for zinc phosphide poisoning.

First aid. Call a doctor immediately. If the victim is conscious, induce vomiting by giving a tablespoonful of salt in a glass of warm water and repeat until vomitus is clear. Give victim milk or white of egg beaten with water. Have victim lie down and keep warm.